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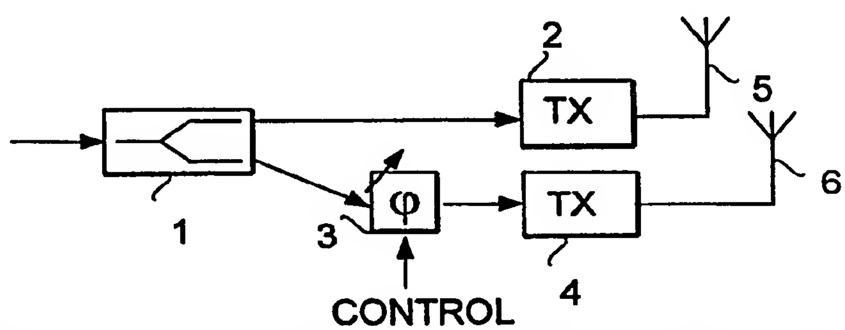
(57) Abstract

The invention relates to a method for transmitting radio-frequency signals by a TDMA transceiver comprising means for transmitting a burst by two antenna means (5, 6) to active radio units located within the coverage area of the transceiver, the antenna means (5, 6) being arranged at a distance (d) from each other. In order that the audibility of signals transmitted by the transmitter could be improved at the receiver, a burst to be transmitted is applied to the first antenna means (5) and after a predetermined delay to the second antenna means (6) in such a way that there occurs a phase difference between signals transmitted by the first and the second antenna means. The invention also relates to a transceiver unit where the method can be applied.



A method for transmitting radio signals, and a TDMA transceiver

This invention relates to a method for transmitting radio-frequency signals by a TDMA transceiver comprising means for transmitting a burst by two antenna means to active radio units located within the coverage area of the transceiver, the antenna means being arranged at a distance from each other, wherein a burst to be transmitted is applied to the first and the second antenna means in such a way that there occurs a phase difference between signals transmitted by the first and the second antenna means. The invention also relates to a TDMA transceiver comprising means for transmitting a radio-frequency burst by two antenna means positioned at a distance from each other to active radio units located within the coverage area of the transceiver, the transceiver comprising a branching means for feeding a burst to be transmitted to a first and a second antenna branch, the first antenna branch comprising the first antenna means, and the second antenna branch comprising the second antenna means and a phase-shifting means for providing a phase difference between bursts transmitted by the first and the second antenna means.

The invention is concerned particularly with a base station transceiver in a cellular radio system, which provides radio communication with active radio transmitters located within the coverage area of the base station. As used in this patent application, the term *burst* refers to a group of signals transmitted during one time slot in time division multiplexing, i.e. to a predetermined number of bits transmitted during a predetermined period of time. The GSM system is one example of a cellular radio system divided into

time slots on the TDMA (Time Division Multiple Access) principle, where signalling takes place in bursts. The structure and operation of the GSM system are described e.g. in *The GSM System for Mobile Communications*, M. Mouly & M-B Pautet, Palaiseau, France, 1992, ISBN: 2-9507190-0-7, wherefore the system will not be described more closely herein.

In cellular radio systems, there often occurs audibility problems particularly at the outer edges of the radio coverage area of a base station. Such problems are due to low signal levels, disadvantageous reflections or external noise signals.

U.S. Patent 4,849,990 discloses a solution where the transmitter and receiver of a base station are duplicated and they process the signal in two separate branches, between which there is a desired delay difference realized by delay means. The solution aims to improve the reliability of a radio link interfered with multipath propagation when DSK, BPSK-RZ or other similar modulation is used. In this solution, one of the transmitting branches of the duplicated transmitter delays a baseband information signal by the delay means before modulation, whereby a significant delay difference occurs between signals transmitted by two separate antenna means as compared with the transmission delay of one information symbol.

One major drawback of this known solution is that a special demodulator has to be provided in the receiver, wherefore existing receivers cannot be used as such. The receiver described in U.S. Patent 4,849,990 comprises two separate high-frequency receivers, wherein a delay means provided in one of the receiving branches delays a signal to be received significantly as compared with the transmission delay of the information symbol, whereafter signals received

from the different receivers are combined and the obtained signal having the original modulation is detected by the demodulator according to the publication. In the solution of the U.S. patent, the delay difference has to be selected in accordance with the duration of the information symbol and the magnitude of the delay spread caused by multi-path propagation.

The specifications of the GSM system offer a few solutions attempting to improve the audibility within a radio cell, such as interleaving of signal groups in the time domain over several bursts and frequency hopping. If the audibility is to be improved by using these measures, it is necessary that the radio unit receiving signals from the base station moves, as these measures are of no use if the radio unit remains stationary at a field strength minimum.

Diversity reception is another solution applicable in the GSM system for improving audibility of radio signals transmitted from a radio unit towards a base station. In this case, the base station receives signals from a specific radio unit by means of two antennas positioned at a distance from each other. Due to reflections, signals transmitted from the radio unit have a greater strength at either one of the antennas. The base station thus comprises measuring means enabling it to measure the signal levels of signals received by the different antennas. On the basis of the measurements, the base station selects the antenna to be used for receiving signals from the radio unit. For practical reasons, however, diversity reception cannot be utilized in the reception of signals from the base station to the radio unit, as it is almost impossible to fit two antennas in the radio unit due to its small size.

The object of the present invention is to solve the above-mentioned problems, and provide a method which allows the audibility of signals transmitted from a base station to a specific radio unit to be improved significantly, even though the radio unit remains stationary during transmission. These objects are achieved by means of a method according to the invention, which is characterized in that the phase difference between the signals transmitted by the first and the second antenna means is adjusted until the signal level of a signal received by a predetermined radio unit is at maximum.

The invention also relates to a transceiver in which the method according to the invention can be applied. The transceiver according to the invention is characterized in that the transceiver comprises means for controlling the phase-shifting means so as to maximize the signal level of signals received by a predetermined radio unit receiving signals from the transceiver.

The invention is based on the idea that when an outbound burst is transmitted by two antennas in such a way that there occurs a phase difference between the signals transmitted from the antennas, the obtained antenna pattern can be adjusted in a desired manner by varying the phase difference in such a way that the field strength minimums of the signal to be transmitted will not be located at a predetermined, possibly stationary radio unit. The antenna pattern can be modified by suitably varying the phase difference so that the field strength maximum will be located at a predetermined radio unit. The invention utilizes the fact that the distance between the antennas is considerably greater than the wave length of the carrier of the signal to be transmitted. In this way, the

signal path of signals transmitted by the different antennas will vary greatly, which is of advantage to the invention, as the varying signal paths create a non-uniform radiation pattern with several maximums separated by narrow minimums. The minimums, of course, occur in a direction where the carriers of the signals transmitted are in opposite phases. The most important advantage of the method and the transceiver according to the invention is thus that they are capable of preventing a stationary or slowly moving radio unit from remaining at a field strength minimum, as in such cases the field strength minimum can be shifted by adjusting the phase difference between the signals transmitted by the antennas of the transceiver.

A first preferred embodiment of the solution according to the invention comprises a transceiver utilizing diversity reception, in which case a bearing for a specific radio unit can be calculated on the basis of a phase difference between signals obtained from the two receiving antennas of the transceiver. The phase difference of the signals to be transmitted by the antennas is then adjusted so that the field strength maximum will be located in the direction where the concerned radio unit is located.

In a second preferred embodiment of the solution according to the invention, the phase difference of signals transmitted by the antennas is adjusted after the transmission of a burst until the signal level of signals received by a receiver unit receiving signals from the transmitter is at maximum. The phase difference is varied between bursts in small steps, e.g. at intervals of 5° until a desired signal level maximum is achieved. The phase difference is thereafter maintained constant until it is detected that the signal level is again decreasing, and the phase-difference

adjustment is restarted.

The preferred embodiments of the method and transceiver unit according to the invention appear from the attached dependent claims 2 to 3 and 5 to 8.

In the following the invention will be described more fully by means of a few preferred embodiments while referring to the attached drawings, in which

Figure 1 shows an antenna pattern created by a transceiver according to the invention;

Figure 2 is a block diagram illustrating a preferred embodiment of the transceiver according to the invention;

Figure 3 is a block diagram illustrating a second preferred embodiment of the transceiver according to the invention; and

Figure 4 is a block diagram illustrating a third preferred embodiment of the transceiver according to the invention.

Figure 1 shows an antenna pattern created by a transceiver according to the invention. The transceiver shown in Figure 1 comprises two antennas 5 and 6, by means of which it transmits radios signals within its coverage area. The antennas are positioned at a distance d from each other. The distance d is substantially greater than the wave length of the carrier of the signal to be transmitted (e.g. 9 times greater). The signal path of signals transmitted by the different antennas will thus vary greatly, which is advantageous as the varying signal paths create a non-uniform radiation pattern with several maximums. In Figure 1, the maximums of the radiation pattern are indicated by lines 14, the phase difference $\Delta\varphi$ between the signals transmitted by the antennas 5 and 6 being 0°. The location of the maximums 14 depends on the distance between the antennas and the phase difference

between the signals transmitted by the antennas 5 and 6. If the phase difference is altered, the maximums shift accordingly. Broken lines 15 in Figure 1 show the maximums of the radiation pattern when the phase difference $\Delta\varphi$ is 180°.

Figure 2 is a block diagram illustrating a preferred embodiment of the transceiver according to the invention. It shows the transmission side of a transceiver fitted in a GSM base station, the reception side being not shown. The transceiver of Figure 2 comprises a branching means 1 which branches an outbound burst into the two antenna branches of the transceiver. In the first antenna branch, the burst is applied from the branching means 1 to the transmitter 2, the output of which is connected to the antenna 5.

In the second antenna branch, the burst is applied from the branching means 1 to a variable phase-shifting means or delay means 3. This phase-shifting means may be e.g. a variable electric or ferromagnetic phase shifter. The output of the phase-shifting means 3 is connected to the input of the transmitter 4, from which the burst is forwarded to the second antenna 6. Due to the phase-shifting means 3, there will occur a phase difference between the signals transmitted by the antennas 5 and 6 positioned at a distance from each other. The magnitude of the phase difference can be adjusted by the phase-shifting means 3 e.g. in such a way that the maximum of the created antenna pattern will be located at a predetermined receiver or, alternatively, in such a way that the phase difference varies randomly between 0° and 180°. The phase difference, however, has to change sufficiently slowly so that it will not affect the modulation of the signal to be transmitted. According to the invention, this is avoided in such a way that

the phase difference is kept constant during the transmission of a specific burst, whereafter it can be changed.

In the case of Figure 2, one possible alternative is to use e.g. the baseband section of the transceiver of the GSM base station as the branching means 1 and the phase-shifting means 3. The same burst is transmitted from this section to the two transmitters 2 and 4 with a small delay between the transmissions.

Figure 3 shows a block diagram illustrating a second preferred embodiment of the transceiver according to the invention. It shows a transceiver fitted in a GSM base station and comprising two antennas used for reception and two receivers for diversity reception. The transmission side of the transceiver shown in Figure 3 is similar to that described with reference to Figure 2. However, rotating means 7 and 8 are provided between the transmitters 2 and 4 and the antennas 5 and 6 in order that the antennas 5 and 6 could be used both for transmitting and receiving signals.

As the antennas 5 and 6 are positioned at a distance from each other, there occurs a phase difference between signals received by the receiver 9 and those received by the receiver 10. Directional couplers 11 and 12 provided on the reception side of the transceiver shown in Figure 3 sample the signals received by the receivers 9 and 10. Accordingly, a control unit 13 is informed of the current phase difference. On the basis of this phase difference, the control unit 13 is able to calculate a bearing for the transmitter the signals of which are being received at a given time. The phase-shifting means 3 is then adjusted so that the field strength maximum of signals

transmitted by the transmitters 2 and 4 is directed towards the radio transmitter from which signals are being received.

Figure 4 is a block diagram illustrating a third preferred embodiment of the transceiver according to the invention. The transceiver section of a GSM base station shown in Figure 4 corresponds to that described with reference to Figure 2 except that it comprises a single transmitter 2. Signals from this transmitter are branched in a branching means 1 having an output to which an antenna 5 is connected and another output to which a phase-shifting means 3 is connected. The phase-shifting means 3 provide a desired phase shift between signals transmitted by the antennas 5 and 6, the output of the phase-shifting means 3 being connected to the antenna 6.

It is to be understood that the above description and the drawings related to it are only intended to illustrate a few embodiments of the invention. Accordingly, the invention also has other applications than the GSM base station, even though the invention has been described above mainly by means of the GSM system. The preferred embodiments of the method and transceiver according to the invention may thus vary within the scope of the attached claims.

Claims:

1. Method for transmitting radio-frequency signals by a TDMA transceiver comprising means for transmitting a burst by two antenna means (5, 6) to active radio units located within the coverage area of the transceiver, the antenna means (5, 6) being arranged at a distance (d) from each other, wherein a burst to be transmitted is applied to the first (5) and the second (6) antenna means in such a way that there occurs a phase difference between signals transmitted by the first and the second antenna means, c h a r a c t e r i z e d in that the phase difference between the signals transmitted by the first (5) and the second (6) antenna means is adjusted until the signal level of a signal received by a predetermined radio unit is at maximum.

2. Method according to claim 1, c h a r a c t e r i z e d in that the phase difference is adjusted after each transmitted burst, until the signal level of the signal received by said radio unit is at maximum.

3. Method according to claim 1, c h a r a c t e r i z e d in that signals transmitted by a predetermined radio unit are received by the two antenna means (5, 6) positioned at a distance from each other, a bearing for said radio unit being calculated on the basis of the phase difference of signals received by the different antenna means, and that the phase difference is selected so that a field strength maximum (14) of signals transmitted by the transceiver is directed towards said radio unit.

4. TDMA transceiver comprising means for transmitting a radio-frequency burst by two antenna means (5, 6) positioned at a distance from each other to

active radio units located within the coverage area of the transceiver, the transceiver comprising a branching means (1) for feeding a burst to be transmitted to a first and a second antenna branch, the first antenna branch comprising the first antenna means (5), and the second antenna branch comprising the second antenna means (6) and a phase-shifting means (3) for providing a phase difference between bursts transmitted by the first and the second antenna means, characterized in that the transceiver comprises means for controlling the phase-shifting means (3) so as to maximize the signal level of signals received by a predetermined radio unit receiving signals from the transceiver.

5. Transceiver according to claim 4, characterized in that a first transmitter (2) is connected to the first output of the branching means (1), and the first antenna means (5) is connected to the output of the first transmitter (2), and that the phase-shifting means (3) is connected to a second output of the branching means (1), the output of the phase-shifting means (3) being connected to a second transmitter (4), to the output of which the second antenna means (6) is connected.

6. Transceiver according to claim 4, characterized in that the transmitter (2) is connected to the input of the branching means (1), the first antenna means (5) being connected to the first output of the branching means, the phase-shifting means (3) to the second output of the branching means (1), and the second antenna means (6) to the output of the phase-shifting means (3).

7. Transceiver according to any of claims 4 to 6, characterized in that the transceiver comprises means for controlling the phase-shifting

means (3) on the basis of signal level measurements performed by a predetermined radio unit receiving signals from the transceiver.

8. Transceiver according to claim 4, c h a r a c t e r i z e d in that the transceiver comprises a diversity receiver (10) in addition to a receiver (9) used in normal communication, means (13) for calculating a bearing for a predetermined radio unit on the basis of the phase difference between signals received by the receiver (9) and the diversity receiver (10), and means (13) for controlling the phase-shifting means in such a way that the phase difference between signals transmitted by the first and the second antenna means (5, 6) is such that a field strength maximum (14) of signals transmitted by the transceiver is directed towards said radio unit.

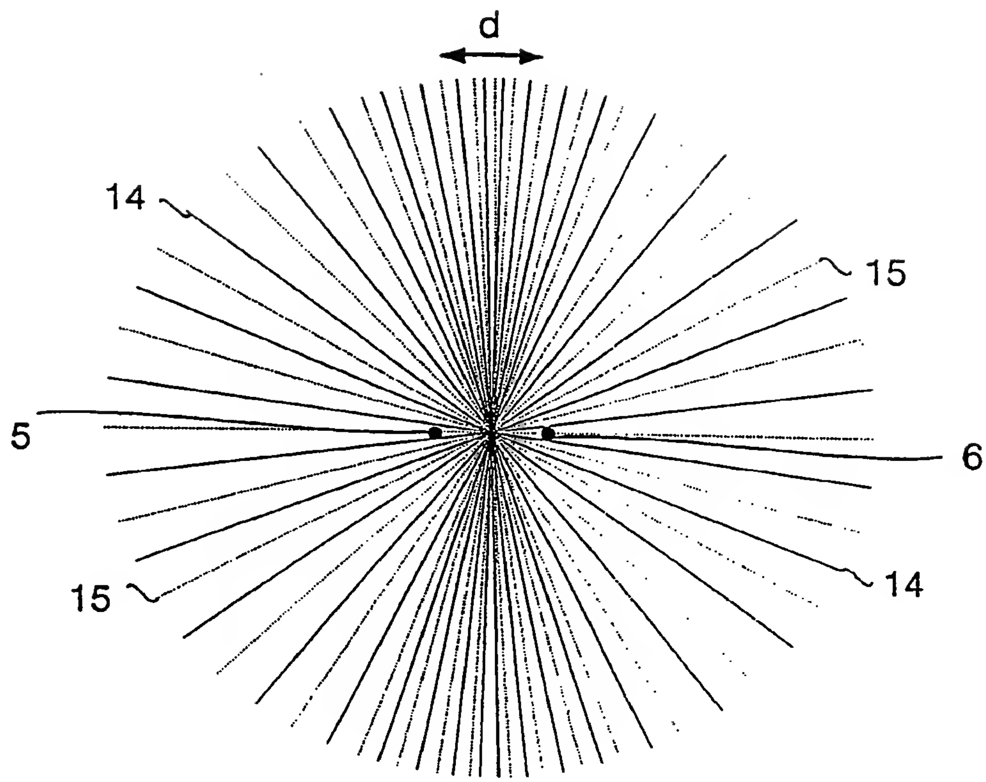


FIG. 1

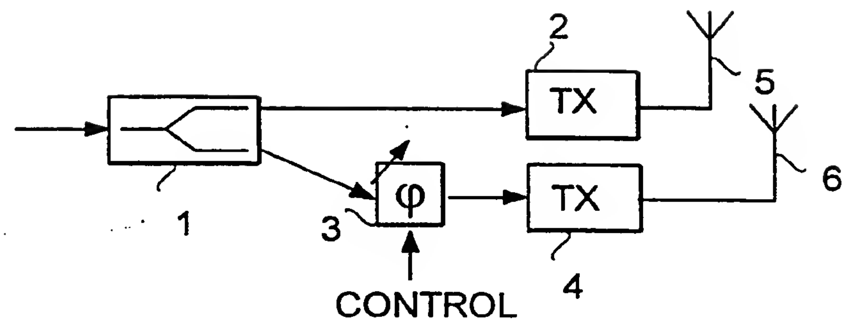


FIG. 2

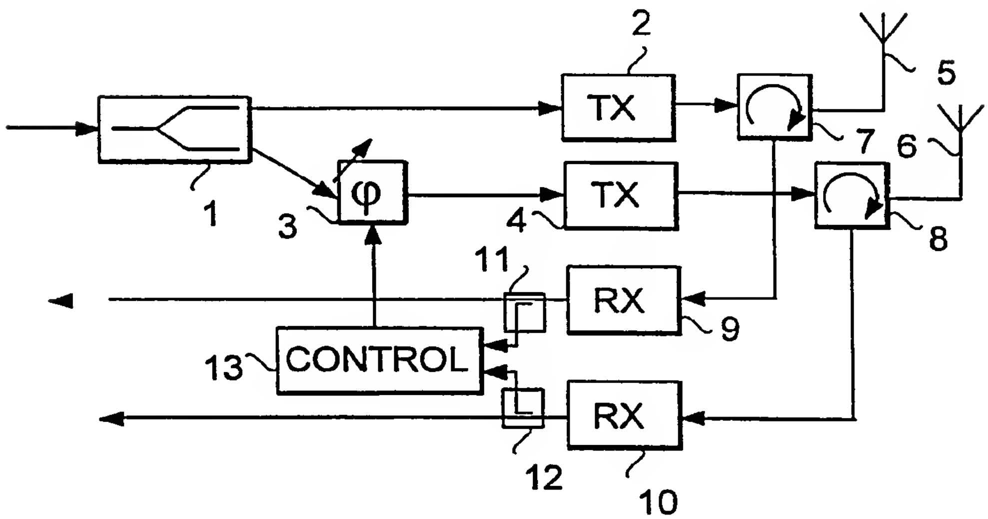


FIG. 3

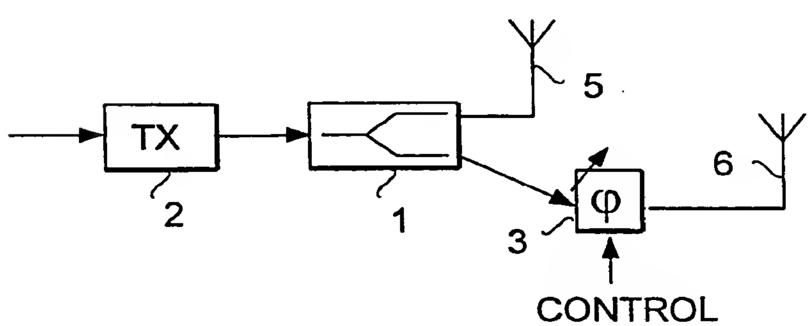


FIG. 4